



Source Apportionment Tools

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Air Toxics Exposure Assessment Workshop

Receptor Model Development and Testing

- Chemical Mass Balance (CMB)
 - EPA CMB 8.2 beta version (Nov. 2002)
- Unmix
 - EPA Unmix 2.3
 - VOC Example from El Paso, TX
- Positive Matrix Factorization (PMF)/
Multilinear Engine (ME)
 - Baltimore Retirement Home Example

EPA Unmix 2.3

- ✍ constrained (non-negativity) factor analysis
- ✍ generates source profiles (& uncertainties) and source contributions from ambient data
- ✍ no explicit use of ambient data uncertainties
- ✍ no free parameters
- ✍ EPA Unmix 2.3 stand-alone version available

Unmix User-Interface



EPA Unmix 2.3

File Set Execute Tools Output Help

Sources

Auto
2
3
4
5
6
7

Analyze

Run

Stop

Clear

Selected Species

#	Name	Obs	Mean
10	ETHYL	317	0.9005
12	ACETE	317	11.8133
13	PRPYL	317	5.9592
14	PROPA	317	39.2256
15	ISBTA	317	8.4345
17	NBUTA	317	34.7515
18	T2BTE	317	0.9005
19	C2BTE	317	0.7484
20	ISPNA	317	24.8790
22	NPNTA	317	15.6868
23	ISPRE	317	0.3467
24	T2PNE	317	1.8024
25	C2PNE	317	0.9152
29	M2PNA	317	9.2968
30	M3PNA	317	6.1166
31	NHEXA	317	9.5610
32	MCPNA	317	7.0864
33	BZ	317	9.1871
35	M2HXA	317	2.5892
36	M3HXA	317	3.7350

←

→

Set

Total

Tracer

Norm

All Species

#	Name	Obs	Mean
1	YR	504	99.0000
2	MONTH	504	11.8571
3	DAY	504	12.2857
4	HOURL	504	11.5000
5	CO	491	1.0817
6	NO	478	48.4268
7	NO2	478	27.7218
8	NOX	478	77.0816
9	O3	485	0.0155
11	ETHAN	317	15.7491
16	BUTE1	317	1.2058
21	PNTE1	317	0.6614
26	DMB22	317	0.9132
27	CYPNA	317	1.4116
28	DMB23	317	2.2186
34	CYHXA	317	3.4012
42	M2HEP	317	0.9977
43	M3HEP	317	1.4219
44	NOCT	317	1.2126
47	STYR	317	0.2272

Analysis Diagnostics

Factor	rsq	Signal/Noise
1	0.67	1272.76
2	0.94	13.77
3	0.94	8.49
4	0.97	4.02
5	0.98	2.33
6	0.99	1.03
7	0.99	0.65
8	0.99	0.38

Filter Parameters: 0.15, 0.29
Weighting Parameters: 0.15, 0.29
FEASIBLE SOLUTION FOUND
See Analysis Results Window

Analysis Results

M2HXA	0.0111	-0.0048
M3HXA	0.0164	-0.0075
TM224	0.0120	-0.0011
NHEPT	0.0175	-0.0069
MCYHX	0.0115	-0.0066
TM234	0.0033	0.0014
TOLU	0.1077	0.0250
EBENZ	0.0179	0.0075
MPXYL	0.0641	0.0048
OXYL	0.0229	0.0043
SUM_PAMS	226.7582	27.3972

Data File :

elp_unmix_input_VOC_PM.txt

Total Mass: SUM_PAMS

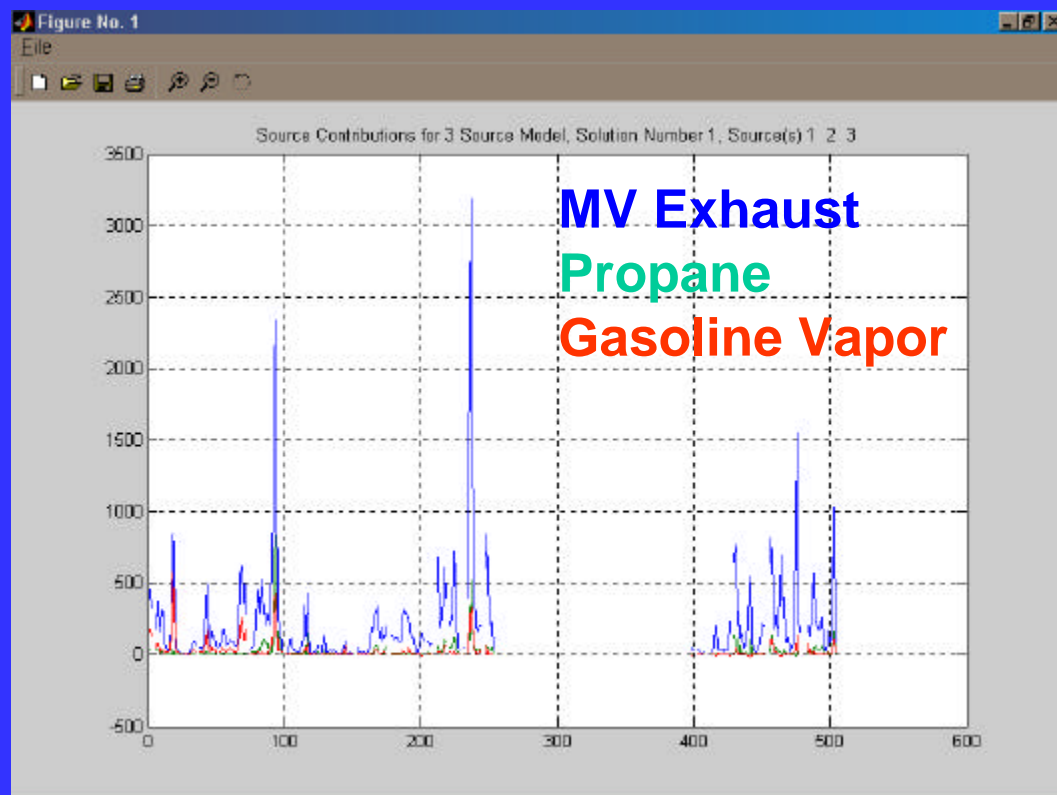
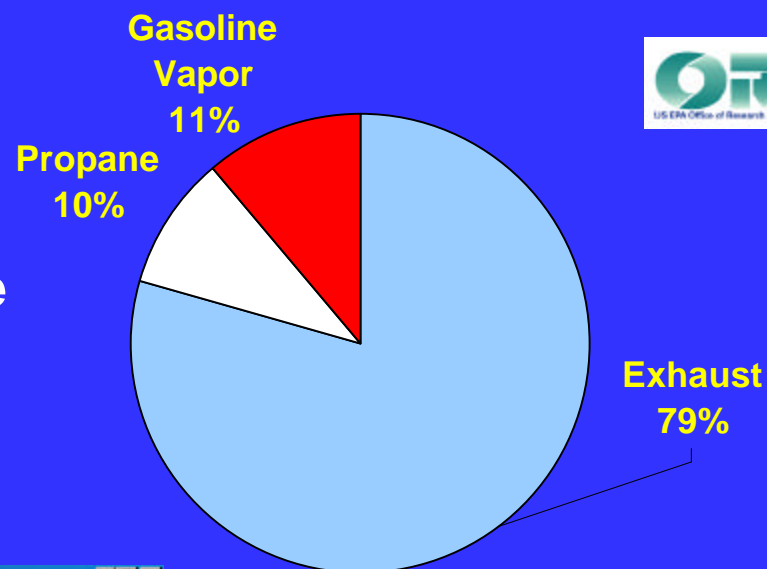
Tracer: ACETE

Normalization: SUM_PAMS

Save Print

El Paso Unmix Results

Average source contribution



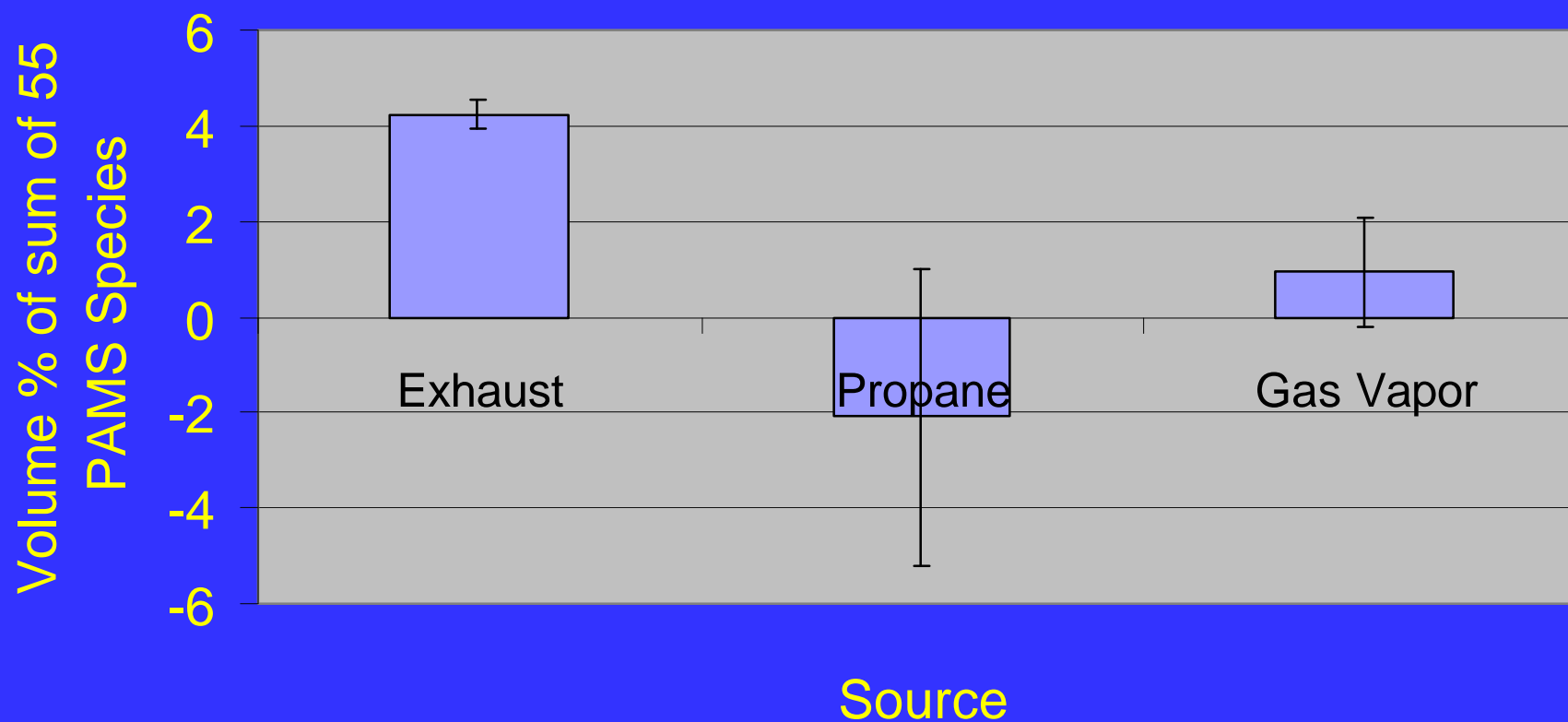
Time series of source contributions



El Paso Unmix Results



Benzene Volume Percent





Source Apportionment of PM Personal Exposure Data

ANALYSIS OF PARTICLE COMPOSITIONS MEASURED IN THE EPA 1998 BALTIMORE EXPOSURE PANEL STUDY

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EPA 1998 Baltimore PM Epidemiology - Exposure Study

PM personal exposure in a sensitive subpopulation

Monitoring period

- July 27 – Aug 22, 1998

Panel

- Elderly subjects with a mean age of 84
- 18 story retirement home facility near Baltimore, MD
- No smoking
- Subjects typically did not cook in their apartments
- Subjects spent 95 % of their time indoors

EPA 1998 Baltimore PM Epidemiology - Exposure Study

Integrated PM_{2.5} measurements (24 hours)

- **Community, Outdoor, and Indoor**

- Versatile Air Pollutant Sampler (VAPS, modified dichotomous sampler)
- Mass, XRF, OC/EC, H⁺, NH₄⁺, NO₃⁻

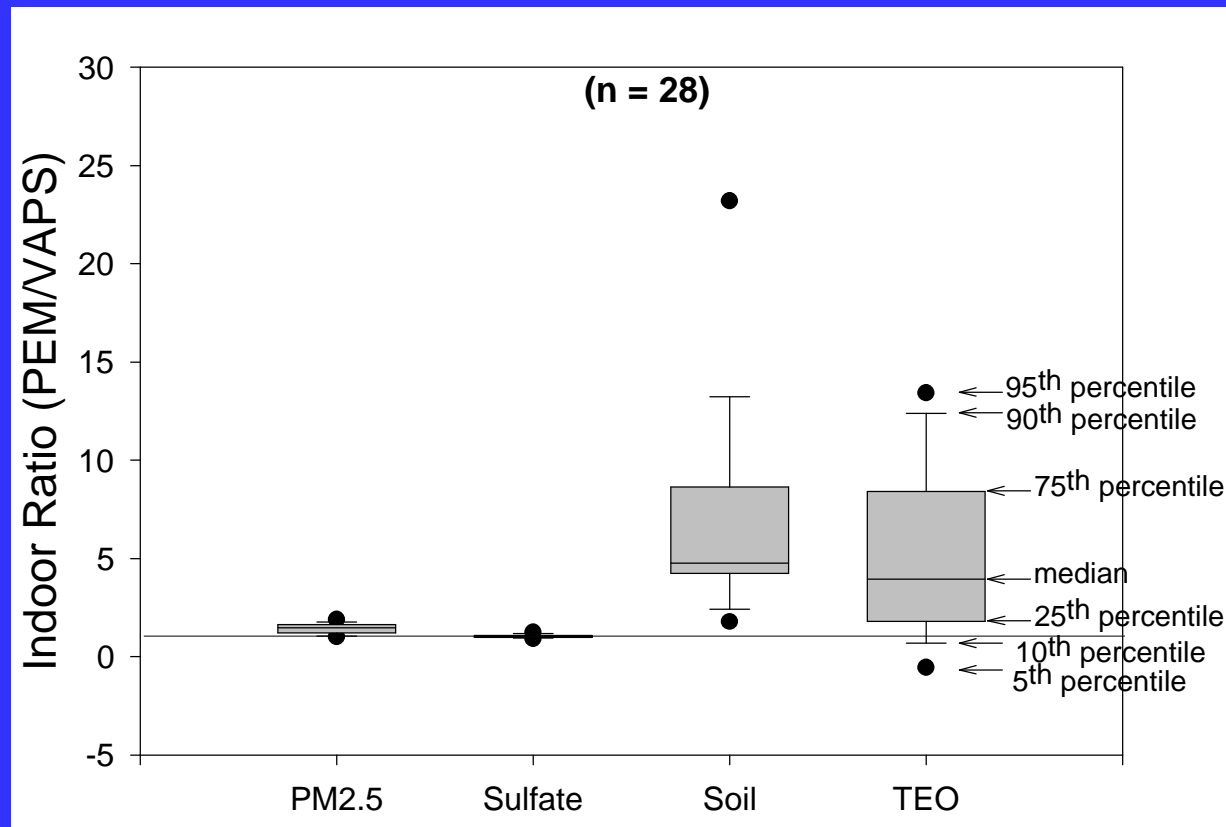
- **Personal, Apartment, Indoor, Outdoor, Community PM_{2.5}**

- Personal Exposure Monitor (PEM) with a PM_{2.5} impactor
- Mass, XRF

Sampling Issue 1



PEM sampler Soil and Trace Element Oxide (TEO) concentrations were higher than the VAPS concentrations.



Based on these results, VAPS and PEM data were analyzed separately.

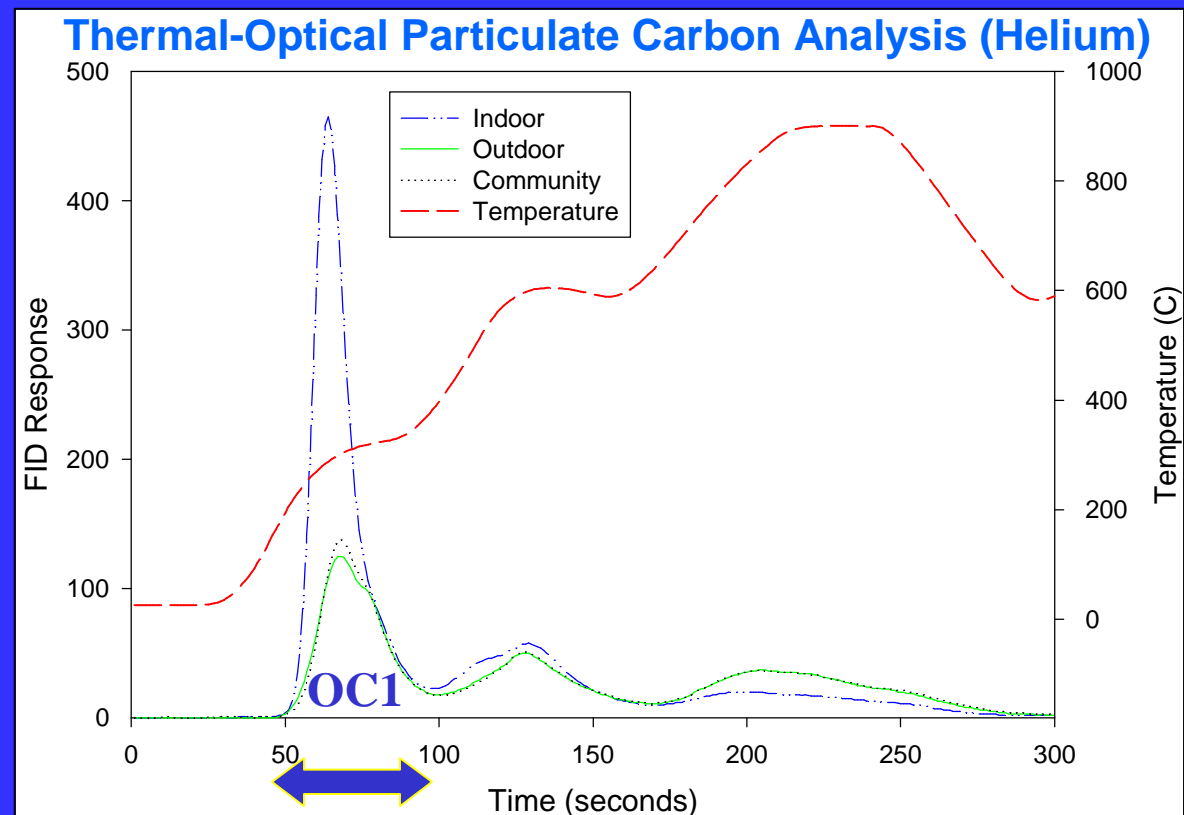
Sampling Issue 2



The organic carbon mass concentration (OC*1.4) collected with a quartz filter was significantly higher than the collocated PM_{2.5} mass concentration collected on a Teflon filter (VAPS) .

**OC*1.4 mass
fraction of PM_{2.5}**

**Community: 34 %
Outdoor: 30 %
Indoor: 168 %**



Sources & Infiltration

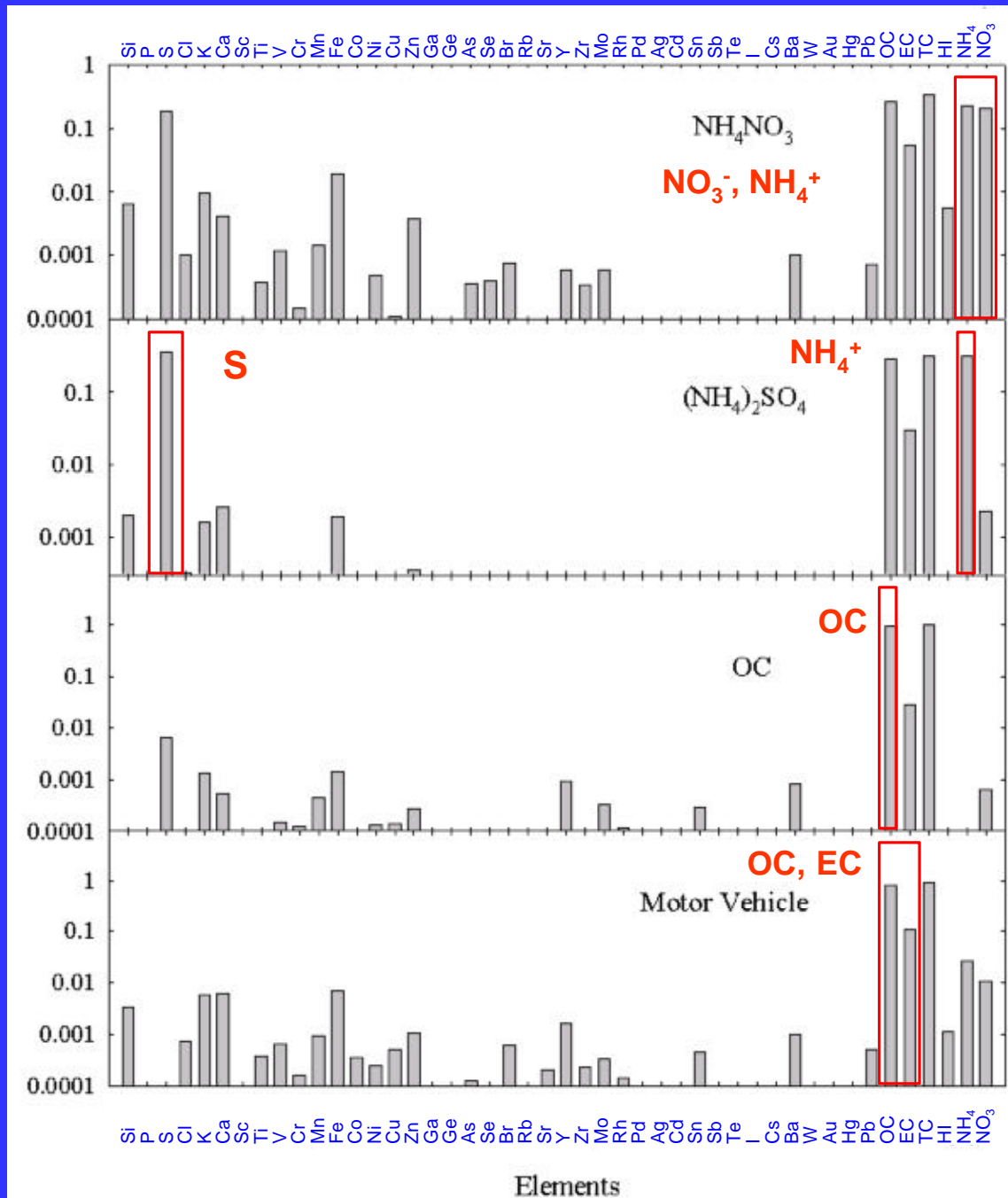
Contribution of $PM_{2.5}$ sources to the Community,
Outdoor, and Indoor Sampling Sites

Positive Matrix Factorization 3

- VAPS data
- Sources contribute to all sites
- Time series pattern the same for all sites
- Relative contribution different for each site

Sources & Infiltration

Source Profiles From 3-way analysis



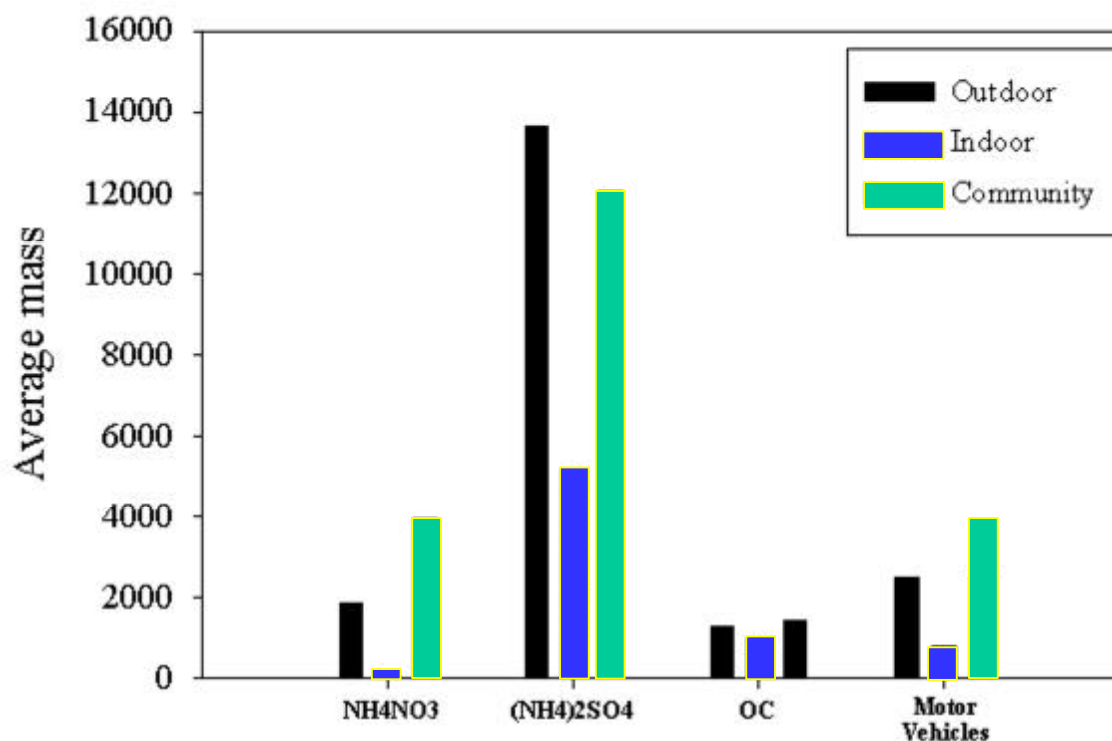
Sources & Infiltration



Average Contributions

Infiltration of
 $PM_{2.5}$ sources
from outdoor
to indoor

$PM_{2.5}$:	35 %
Nitrate:	1.4 %
Sulfate:	43%
OC:	68 %
MV Exhaust:	32 %



Sources & Personal Exposure

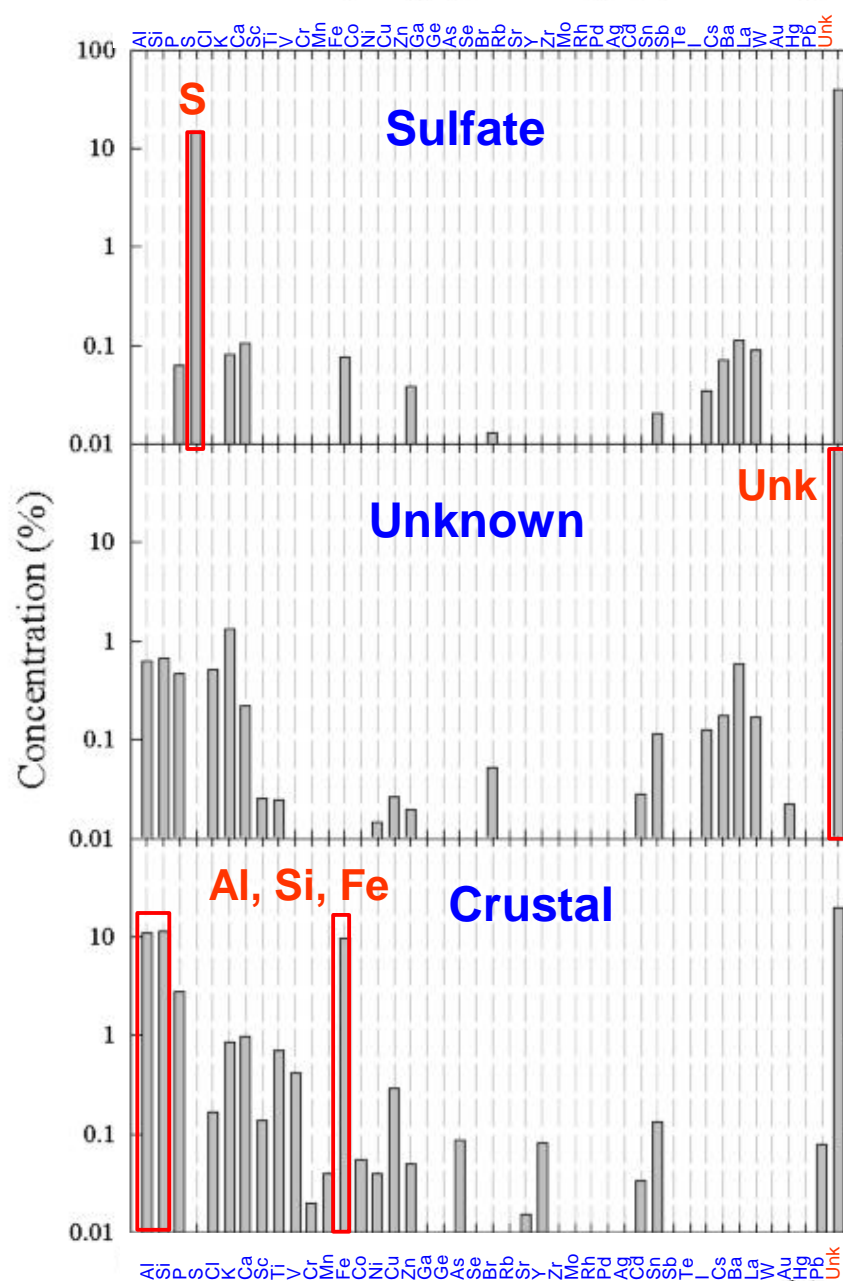


Sources of $PM_{2.5}$ Contributing to Personal Exposure

- PEM data
- Multilinear Engine 2
 - External factors contribute to all four environments (outdoor, indoor, personal, apartment).
 - Internal factors only contribute to personal and apartment samples.
 - Penalty function used to reduce the importance of the internal factors in the fitting process.
 - Make sure that as much of the observed concentration as possible is explained by external factors.

Sources & Personal Exposure

External Factors



Contribution

Personal: 48.4 %

Apartment: 68.6 %

Personal: 12.2 %

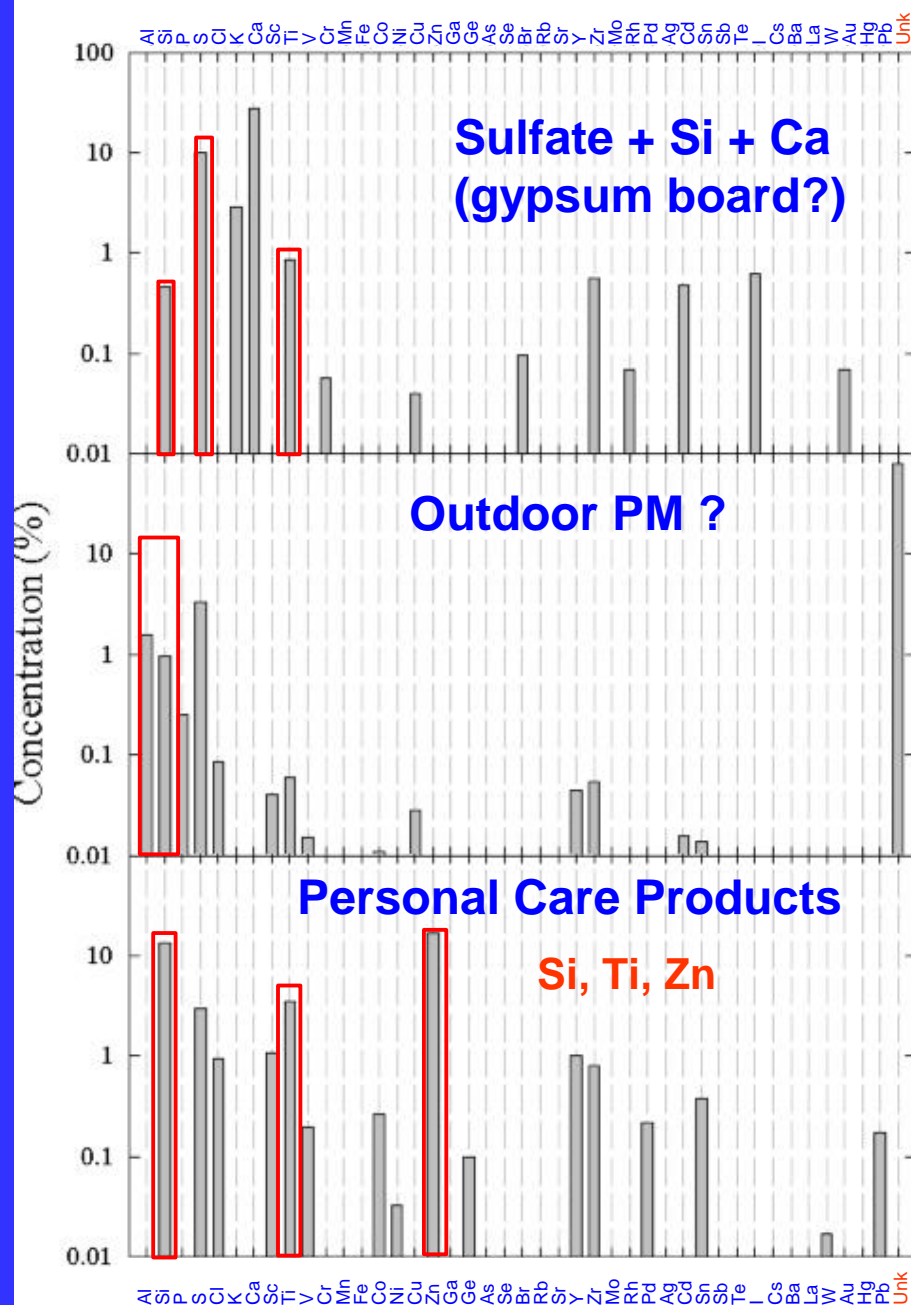
Apartment: 12.3 %

Personal: 2.4 %

Apartment: 2.5 %

Sources & Personal Exposure

Internal Factors



Contribution

Personal: 0.6 %

Apartment: 0.2 %

Personal: 36.1 %

Apartment: 16.1 %

Personal: 0.4 %

Apartment: 0.2 %

Unidentified Outdoor PM Source?

Measured on personal and apartment samples but not by the stationary outdoor and indoor monitors.

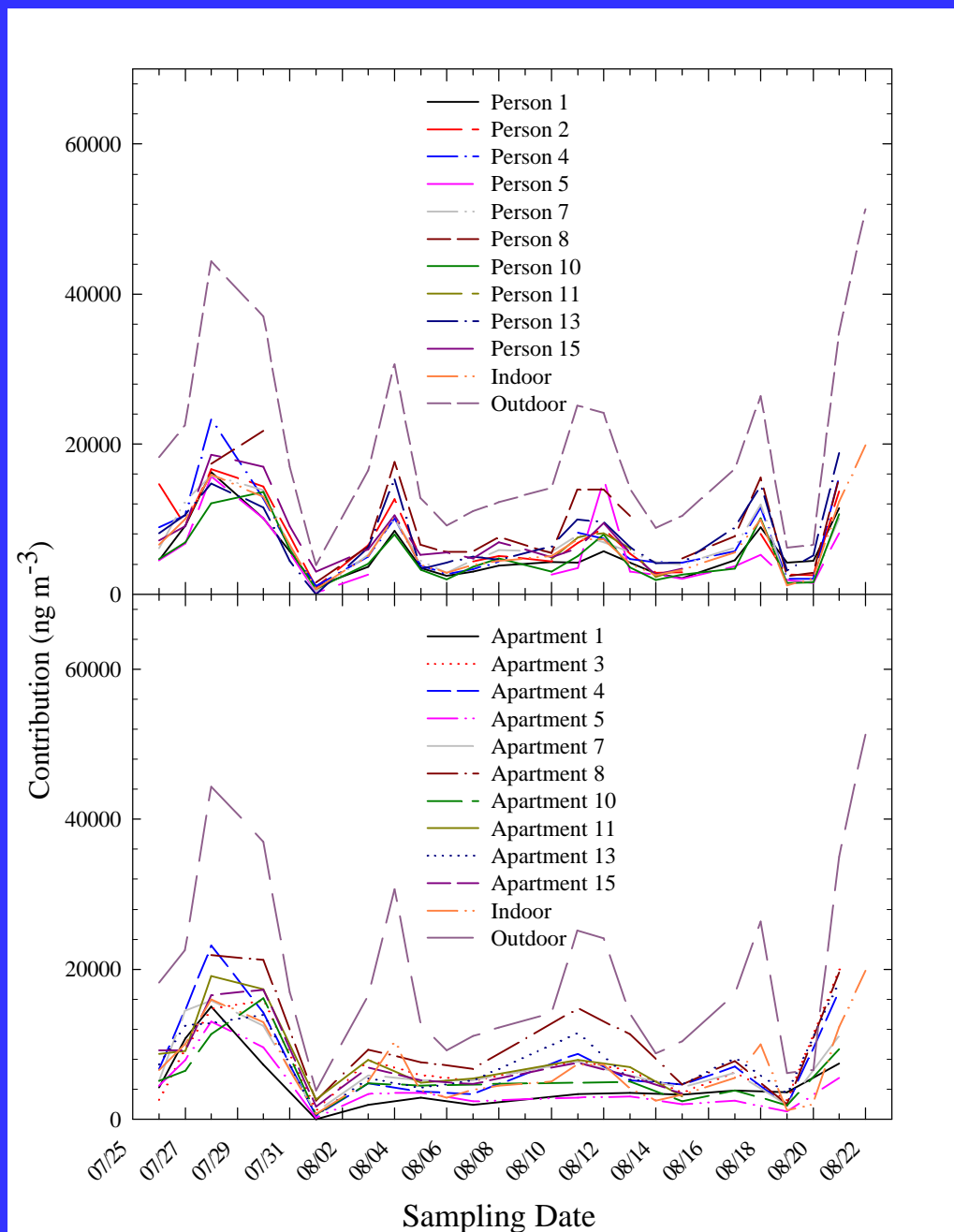
- Need to evaluate the relationship between the time spent outdoors and in vehicles with the Outdoor PM contribution.
- Include activity data and PM species in the receptor model. This could help identify sources contributing to the Outdoor PM.



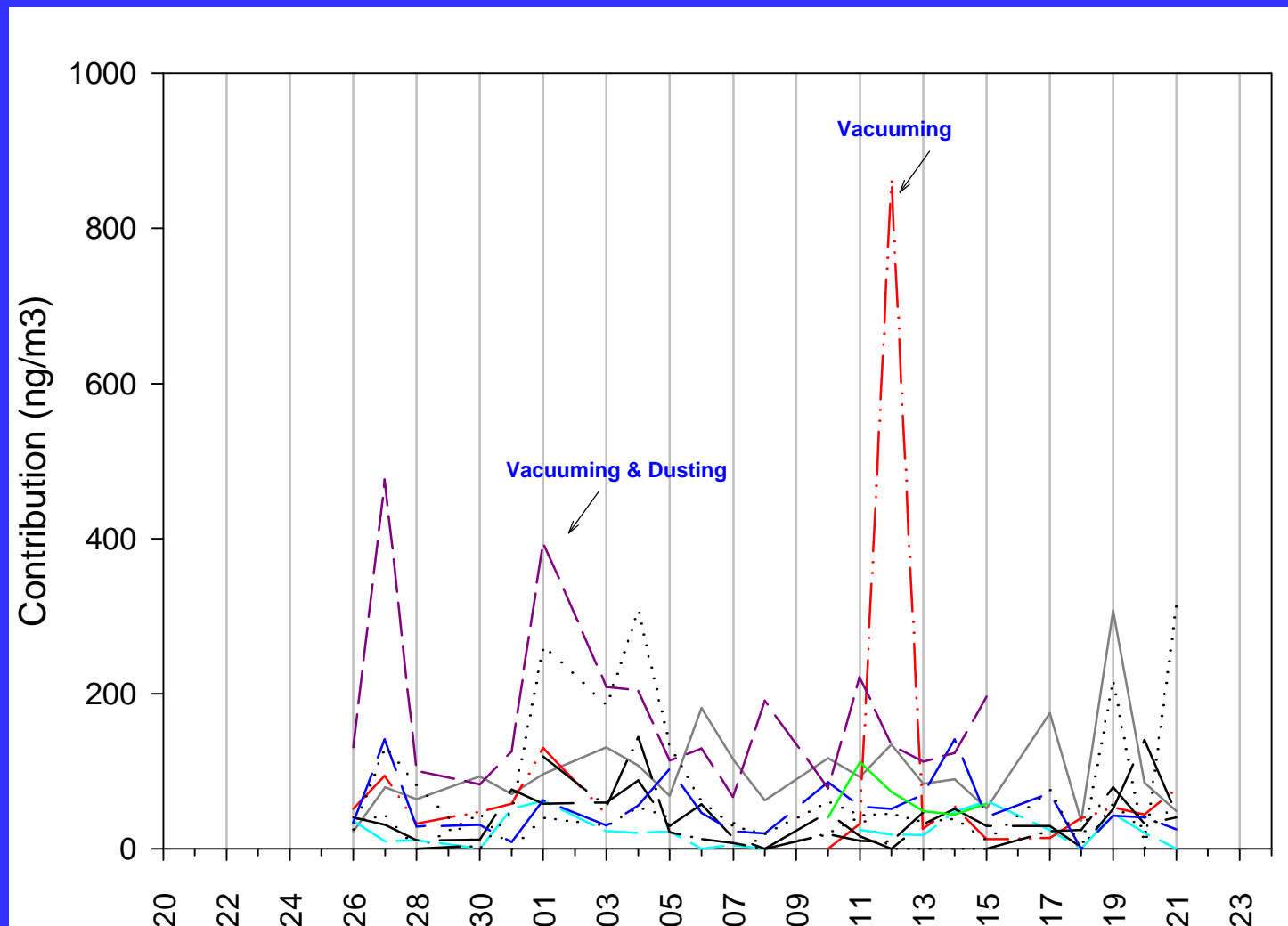
Sources & Personal Exposure

Time series
of external
factor 1:

Sulfate



Source Contributions of Internal Factor 1



Personal Exposure to Motor Vehicle Exhaust



Can we determine personal exposure to motor vehicle PM exhaust ?

Problems

- Pb is no longer a tracer for motor vehicle exhaust
- Large OC positive artifact on indoor and personal samples (EPA Panel Study Data)

Research Areas

- † Add OC1 to the receptor model to estimate OC artifact
- † Quantify EC on Teflon filters using transmittance
- † Use time activity data in the receptor model